GRUAN GNSS Precipitable Water Task Team

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What is GRUAN?

The Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN) is an international reference observing network, designed to meet climate requirements and to fill a major void in the current global observing system. GRUAN observations will provide long-term, high-quality climate records from the surface, through the troposphere, and into the stratosphere. These will be used to determine trends, constrain and validate data from space-based remote sensors and to provide accurate data for the study of atmospheric processes. GRUAN is envisaged as a global network of 30-40 stations, possibly built on existing observational networks and capabilities.

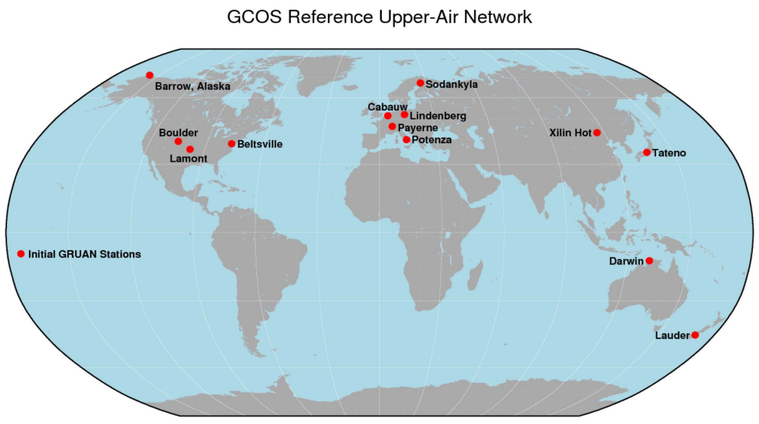
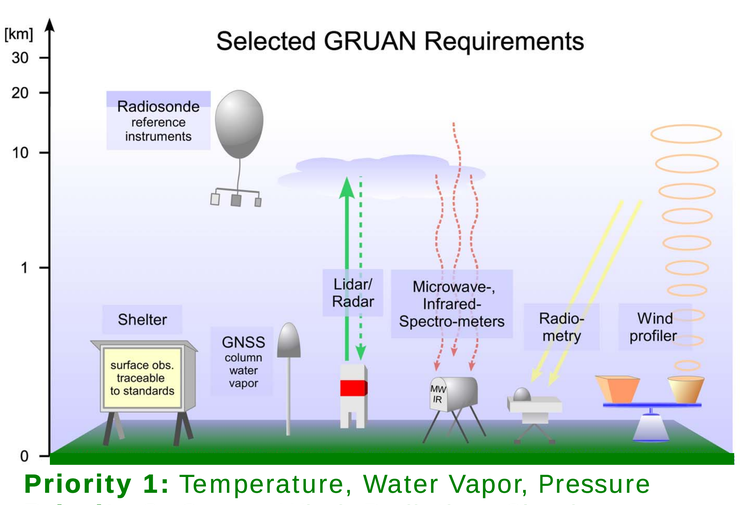


Figure 1: The GRUAN network, initial sites.

GRUAN goals:

- Provide long-term high-quality upper-air climate records
- Constrain and calibrate data from more spatially-comprehensive global observing systems (including satellites and current radiosonde networks)
- Fully characterize the properties of the atmospheric column and their changes (fig.2)
- Measure a large suite of co-related climate variables with deliberate measurement redundancy
- Focus efforts on characterizing observational biases, including complete estimates of measurement uncertainty
- Ensure traceability of measurements by extensive metadata collection and comprehensive documentation of observational methods;
- Ensure long-term stability by managing instrumental changes
- Tie measurements to SI units or internationally accepted standards
- Ensure that potential gaps in satellite programs do not invalidate the long-term climate record, thus leading to improved satellite data products
- Further the understanding of climate variability and change.



Priority 1: Temperature, Water Vapor, Pressure
Priority 2: Ozone, Wind, Radiation, Clouds, Aerosols, ...

Figure 2: Schematic set-up of a GRUAN station

Key scientific questions to be addressed by GRUAN

- Characterizing of changes in temperature, humidity, and wind
- Understanding the climatology and variability of water vapour, particularly in the Upper Troposphere/Lower Stratosphere region as it is of crucial importance for ascertaining climate sensitivity
- Understanding changes in the hydrological cycle
- Understanding and monitoring tropopause characteristics
- Understanding the vertical profile of temperature trends
- Bringing closure to the Earth's radiation budget and balance
- Understanding climate processes and improving climate models.

GRUAN Structure

- GCOS/WCRP AOPC Working Group on Atmospheric Reference Observations (WG-ARO)
- GRUAN Lead Centre at the Lindenberg Meteorological Observatory (DWD)
- GRUAN sites world wide (currently 15 to be expanded to 30-40)
- GRUAN task teams for:
  - Radiosondes
  - GNSS Precipitable Water (PW)
  - Measurement schedules and associated site requirements
  - Ancillary measurements
  - Site representation
- GRUAN Analysis Team for Network Design and Operations Research (GATNDOR)

The GNSS PW Task Team

The GRUAN GNSS precipitable water (GNSS-PW) Task Team (TT) was established in summer 2010 as one of six GRUAN TTs. TTs are charged with addressing critical GRUAN requirements. Ground-based GNSS PW was identified as a Priority 1 measurement for GRUAN, and the GNSS-PW TT's goal is to develop explicit guidance on hardware, software and data management practices to obtain GNSS PW measurements of consistent quality at all GRUAN sites.

Duties and responsibilities

- Define GRUAN requirements for GNSS-PW observations (1)
- Review status of GNSS instruments and data processing methods at GRUAN sites (2)
- Define GRUAN requirements for a state-of-the-art GNSS stations (3)
- Develop guidance on the type, amount, format, temporal resolution and latency of data/metadata needed to be stored from the ground-based GNSS measurements (4)
- Identify best practices in making and verifying GNSS observations for GRUAN and other climate applications defined in Task 1 (5)
- Provide guidelines for GNSS-PW uncertainty analysis (according to Immler et al.) (6)
- How to better manage changes applied to ground-based GNSS measurements in both hardware and software and to make sure that the changes will be taken into account for long-term data analysis (7)
- Encouraging and recommending experiments and research for resolving the tasks mentioned in the subtopics 1-7 (8)

GRUAN GNSS product requirements

Variable	ZTD	ZWD	PW	P_s	T_m
Measurement range	1000 – 3000 mm	0-500 mm	0 – 80 mm	500-1100 hPa	200 – 300 K
Precision	6 mm	6 mm	1 kgm^{-2}	0.01 hPa	0.2 K
Accuracy	6 mm	6 mm	1 kgm^{-2}	0.5 hPa	0.1 K
Long-term stability	0.1-0.4 mm/dec	0.1-0.4 mm/dec	0.02-0.06 kgm^{-2}/dec	0.1 hPa/dec	0.05 K/dec
Temporal resolution	1 h	1 h	1 h	1 h	1 h
Data latency	1 month	1 month	1 month	1 month	1 month

Collaboration with IGS Troposphere WG

- Several members of GRUAN GNSS TT contribute to IGS Tropo WG already
- Common issues could be discussed (e.g. guidelines, tasks, products, formats)
- IGS could help to push GNSS based climate applications according to the climatological requirements as far as possible
- In the long range all GRUAN stations should become IGS stations
- It would be desirable to reprocess the IGS data for climatological applications
- IGS could help to establish Central Processing and Analysis facilities (key issue)

Synergy to/with other international activities

- GRUAN TT work is coordinated with several international activities
- European Union project GfG[2] (www.gfg2.eu) to establish GNSS as international and interdisciplinary field in the context of Global Earth Observation (GEO) including GNSS based climate observations
- E-GVAP 13 GNSS analysis centers, 15 meteorological services, 1600 stations, 3rd period (2014-2018) in preparation
- New COST action of the European Union: Advanced Global Navigation Satellite Systems tropospheric products for monitoring severe weather events and climate (GNSS4SWEC), final proposal to be submitted
- Synergy of GRUAN with GGOS sites is currently under evaluation
- In addition there are several national activities and research projects related to the use of GNSS for weather and climate

Partners:

- National contributors (fundamental to success of the enterprise) currently: BoM, CMA, CNR, DOE/ACRF, DWD, FMI, Howard University, JMA, KNMI, MeteoSwiss, NIWA, NOAA, NCAR
- Existing observational networks (NDACC, ARM, GAW, BSRN, GUAN, GSN)
- The Global Space-based Inter-calibration System (GSICS) and The "Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring" (SCOPE-CM) Initiative
- The climate science community
- WMO; its Commission for Instruments and Methods of Observations (CIMO); Commission on Climatology (CCI); Commission for Basic Systems (CBS); The World Climate Research Programme (WCRP)

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GCOS GLOBAL CLIMATE OBSERVING SYSTEM